Terrain Interoperability Research

at

The Institute for Simulation & Training

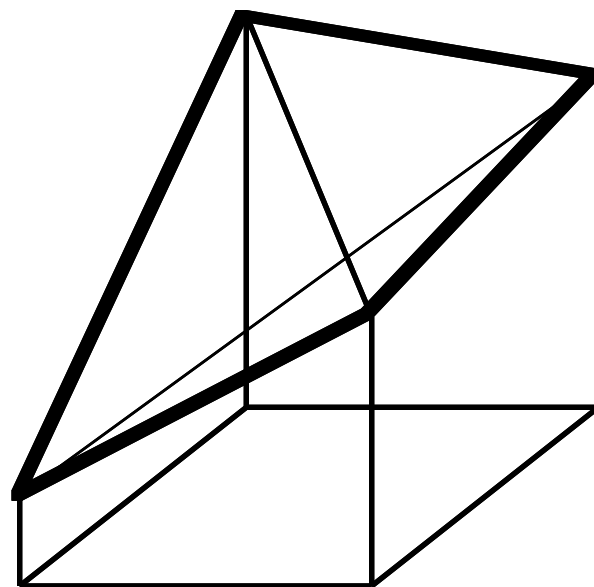## University of Central Florida

Brian Goldiez & Guy Schiavone

Multi-Resolution Environments
(Discussion Topics)

- **Correlation Across Broad Range of Applications**

- **Effect of Granularity and Resolution**

- **Data Loss**
  - *- Measurement*
  - *- Minimization*

- **Consistency Between Environments**

- **Tools, Methods, & Techniques**

Multi-Resolution Environments (Domain)

Algorithm Variations

- **Variations in**
  - *Object Quantity*
  - *Polygon Quantity*
  - *Algorithms*
- **Correlation**
  - *Object Placement*
  - *Building Block (Polygon) Placement*
  - *Attributes (e.g.. size)*
  - *Interactions of Above*
- **Compliance, Compatibility & Interoperability**
- **Multi-Resolution and Spatial Correlation Closely Related**

Multi-Resolution Issues

- **Defining the Baseline Data**
- **Tracking Changes to Data**
  - *Format Changes*
  - *Sampling Changes*
- **Addressing Discontinuities**
  - *Omissions*
  - *Additions*
- **Data Utilization**
- **Fitness for Use In Single & Multiple Domains**
- **When Multi-Resolution Issues are Addressed in Program Development**

Multi-Resolution is Difficult
(Similar to DIS/ADS/HLA)

- **No Compliance Baselines**

- **Variability in Human Behavior**

- **Variability of Simulation Mission**

- **Terms Lack Definition**

- **Terms Have Multiple Meaning**
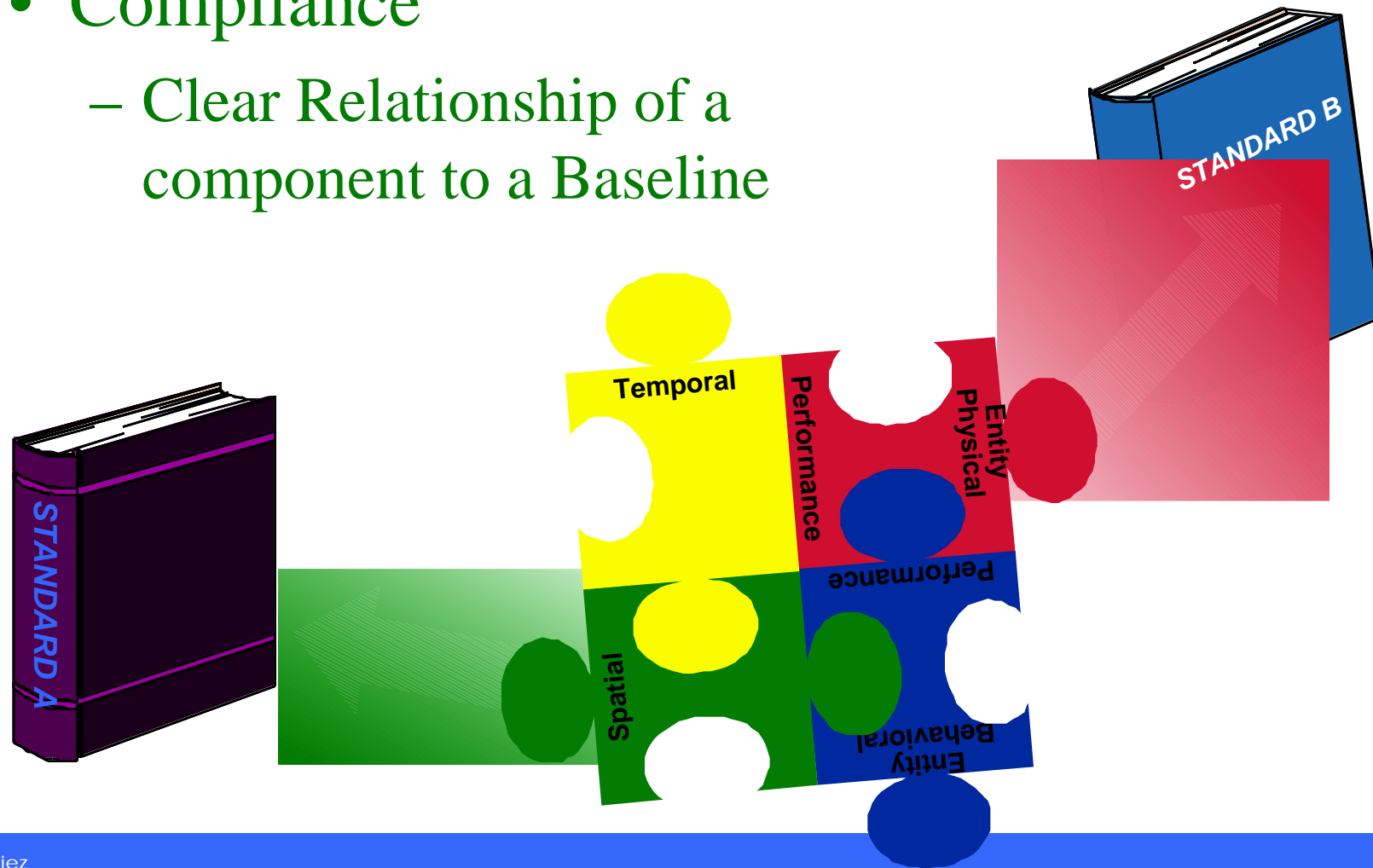
- **Subjectivity in Acceptability**

Simulator Interoperability Components

- Spatial
- Temporal
- Entity Physical Performance
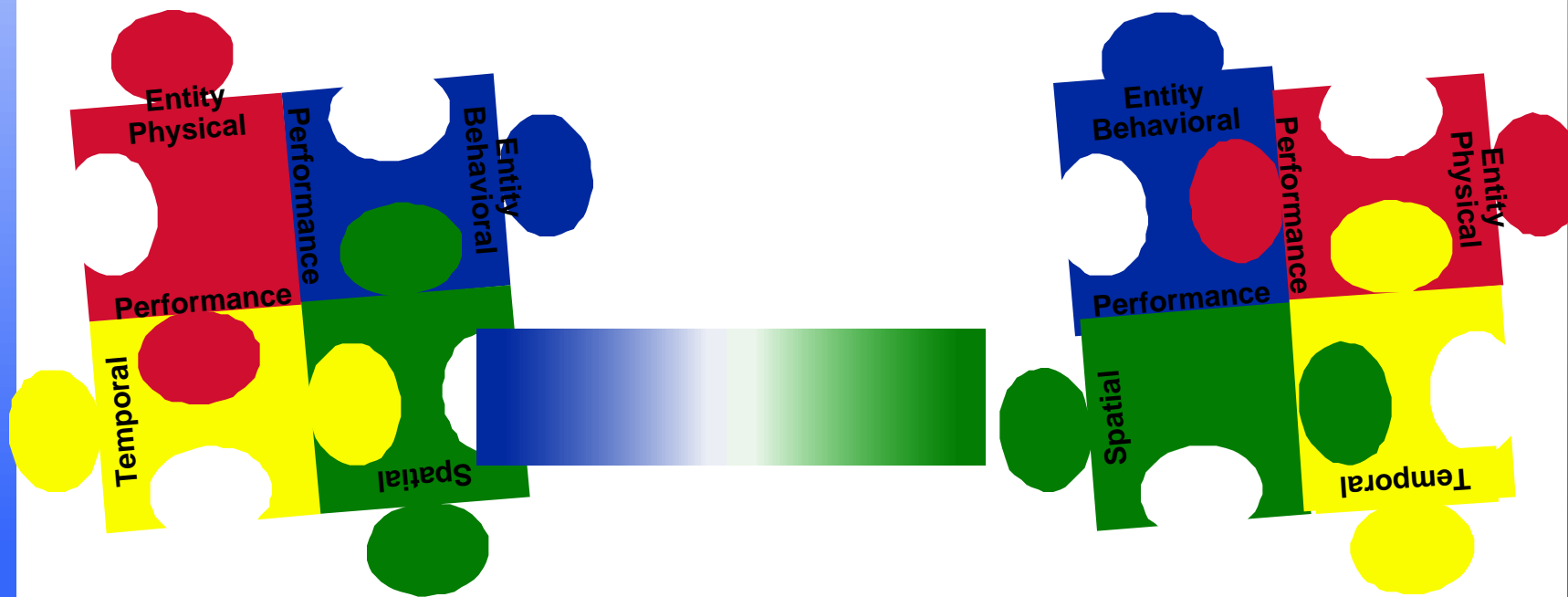- Entity Behavioral Performance

Hierarchy of Interaction

- Compliance
  - Clear Relationship of a component to a Baseline

STANDARD B

STANDARD A

Temporal

Performance

Entity Physical

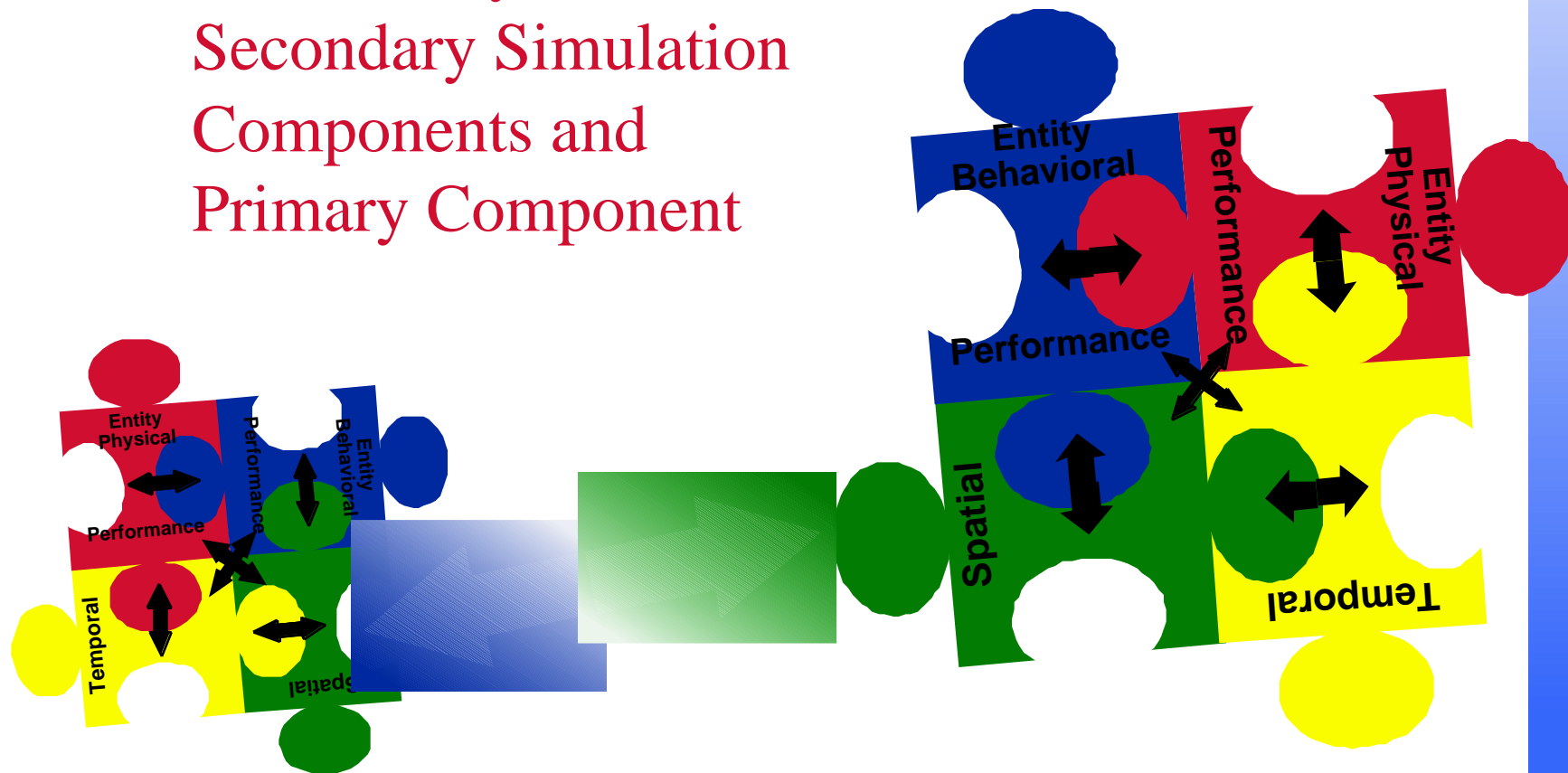Spatial

Performance

Entity Behavioral

Hierarchy of Interaction

- Compatibility
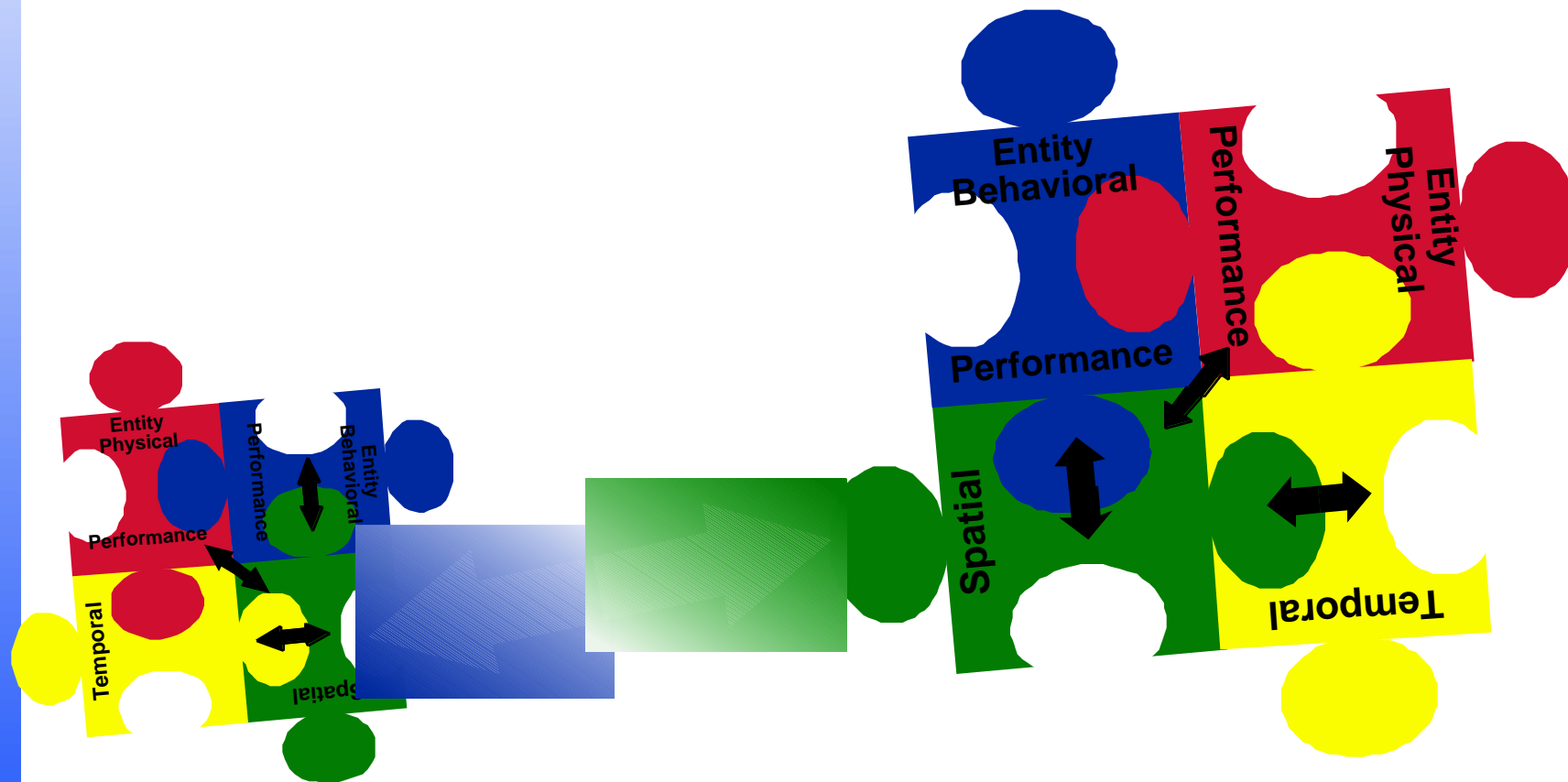 - Consistency Between Primary Simulation Components

Hierarchy of Interaction

- Interoperability
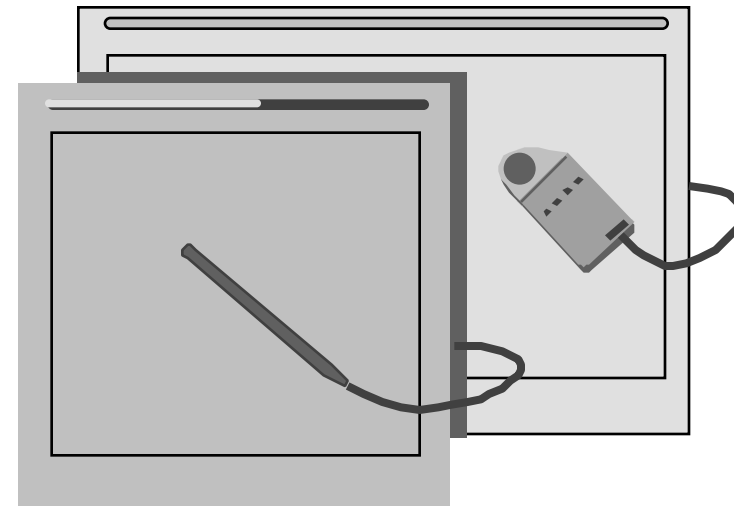 - Consistency Between Secondary Simulation Components and Primary Component

Spatial Interoperability

Multi-Resolution Spatial Interoperability
(Data Acquisition)

- **Mathematical**
- **Statistical**
- **Wide Range of Input Formats**
- **Human Subjects**
- **CGF**

Multi-Resolution Spatial Interoperability
(Acceptable Assessment Method)

- **Iterative, Results Oriented Process**
- **Extensible**
- **Fast**
- **Quantitative**
- **Non-Threatening to Programs**
- **Human Operator Evaluation**
  - *As Participant*
  - *As SME/Observer*
- **Evaluation Using Computer Generated Forces (Preferred Approach)**
- **More Research & Access to Data Necessary**

Assessment Tool - ZCAP

- **General Collection of Correlation Tools & Methods Developed by IST**

- **Developed as a Result of I/ITSEC '92**

- **Extended to Meet Perceived Needs of M&S Community**

- **Currently SGI Based**

- **Government Funded Development**
  - *DMSO*
  - *STRICOM*

- **Available (Source & Executable)**

- **Installed at Several Sites**

ZCAP Data Analysis Tools

ZCAP 2.0

- *Compute Terrain Statistics*
- *Contour*
- *Convert Coordinates*
- *Feature Overlay*
- *Generate Sample Points*
- *Interpolate*
- *Non-uniform Sampling*
- *Query SIF elevations*
- *Shift Detect*
- *Triangulation*

ZCAP 3.0

- *All ZCAP 2.0 Features*
- *Convert OpenFlight SDL Culture*
- *Convert S1000 Culture*
- *Convert SIF Culture*
- *Culture Correlation Test*
- *LOS Correlation Test*
- *LOS Visualization Test*
- *3D Model Similarity w/ Neural Networks*
- *Query S1000 Elevation*
- *Query OpenFlight SDL Elevation*
- *Query SIF Elevation*
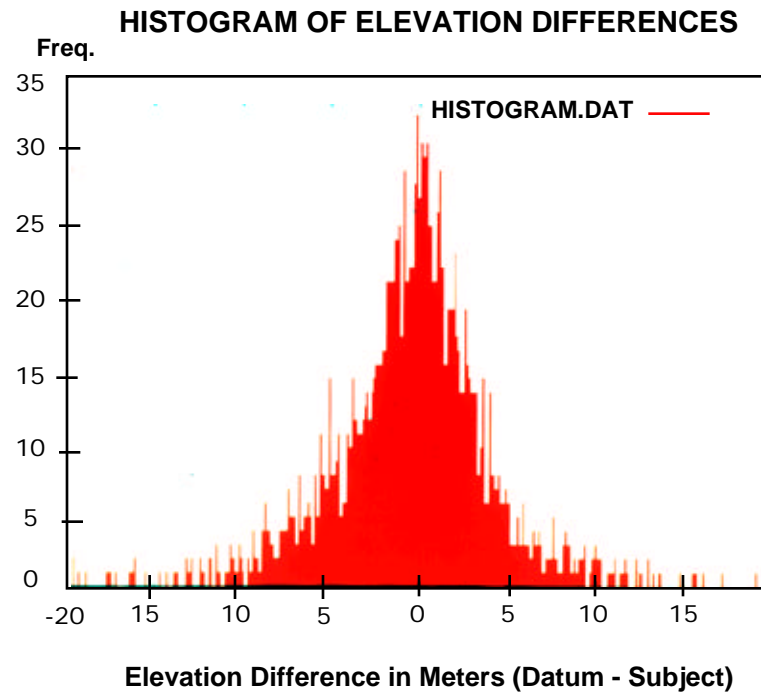
ZCAP Data Analysis Tools

ZCAP 4.1

- *Integrated and Enhanced 3D Visualization Tool*
  - **Improved GUI**
  - **Side-by-side Stealth**
  - **User-Definable Color Mapping**
  - **Data-Specific Feature Legend**
- *Terrain Remediation by Optimal Surface Fitting*
- *Iterative TIN Enhancement to Triangulation Tool*
- *Prototype Correlation Tools*
- *Image Correlation Tools*
- *Image Complexity Metrics*
- *Port to TCL7.5/Tk4.1*
- *Sample Terrain Elevation from MRTDB (CCTT SAF)**
- *Sample Terrain Elevation from SIF++ (CCTT interim format)**
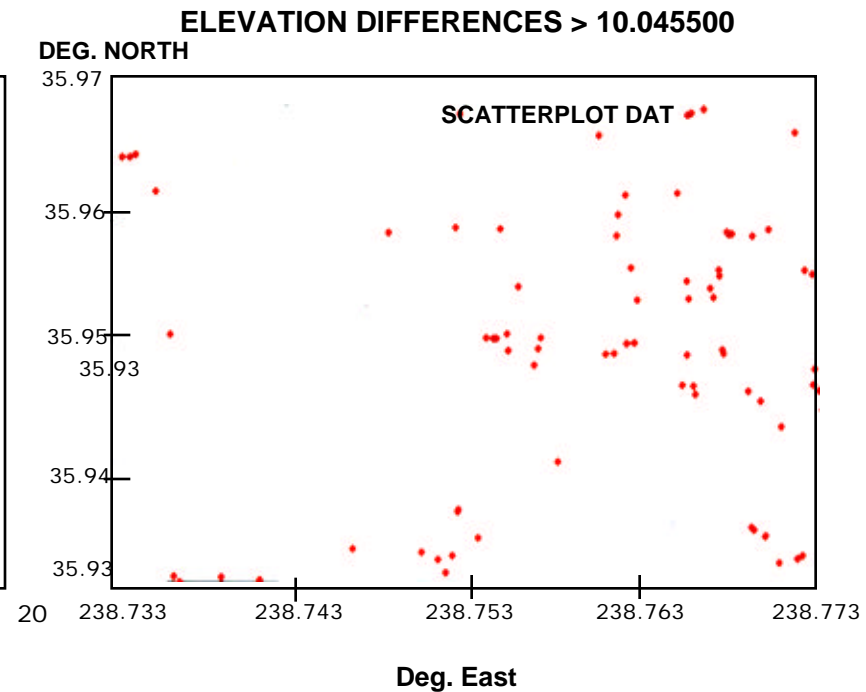
* Under Development (8/96)

Data Analysis Tools: ZCAP Statistics Computation Sample Output

Histogram of Altitude Differences Between 2 Databases

Scatter Plot of Altitude Differences Above the Critical Value

HISTOGRAM OF ELEVATION DIFFERENCES

Elevation Difference in Meters (Datum - Subject)

ELEVATION DIFFERENCES > 10.045500

Deg. East

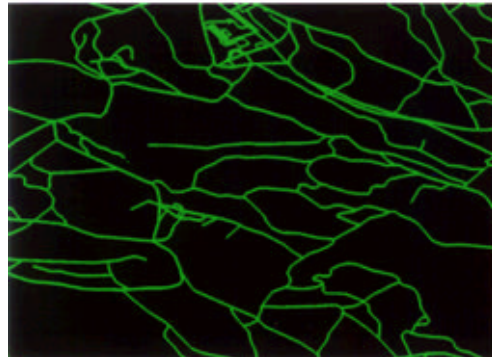# Data Analysis Tools: ZCAP Feature Overlay Visualizer Example

Database #1 (Road Network)

**Overlay comparison of Road Networks
From the Two Databases**

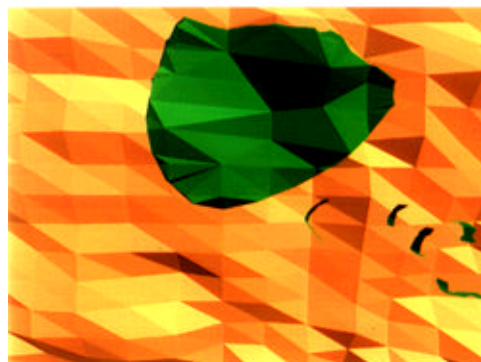**Database #2 (Road Network)**
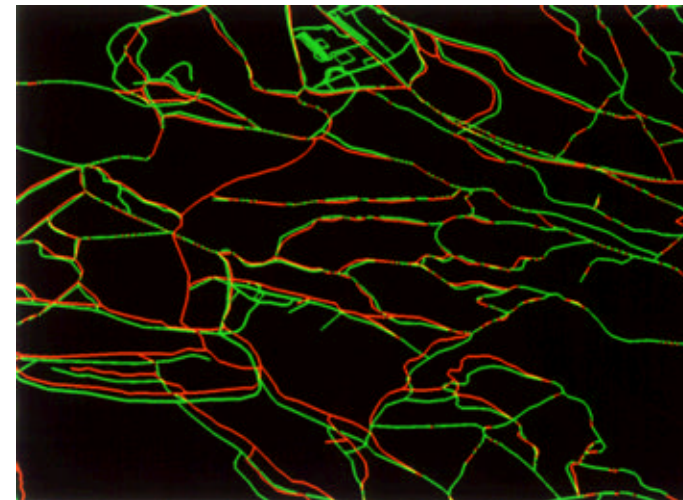
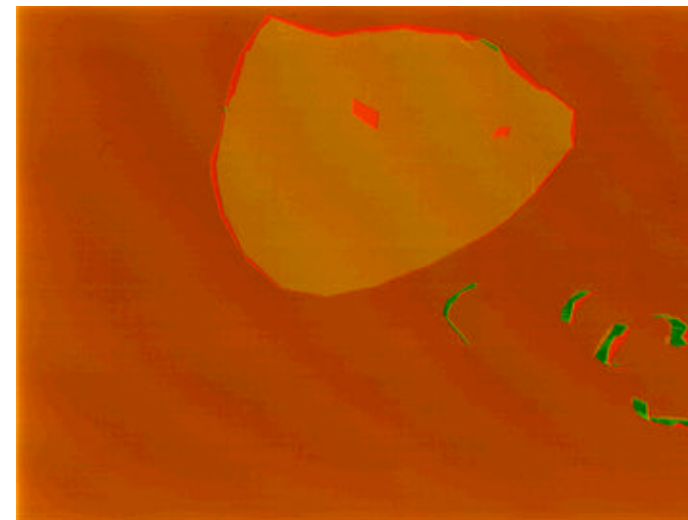# Data Analysis Tools: ZCAP Feature Overlay Visualizer Example

Database #1 (Tree Line)
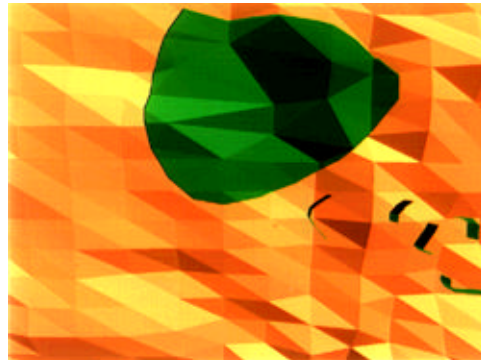
Database #2 (Tree Line)

Overlay comparison of Tree LinesFrom in Databases 1 and 2

PLANNED ZCAP 4.1 INPUT COMPATIBILITY MATRIX*

Terrain Database Format	Z Correlation Test Tools *(3D Terrain Elevation Sample Points)*	2D Feature Overlay Tool *(2D Culture Vector Features)*	3D Visualization Tool *(Feature Overlay, Side-by-Side Stealth, Line-of-Sight (LOS), Contour Overlay),* **LOS Correlation Tool, Culture Correlation Tool, Terrain Remediation Tool** *(3D Culture & Terrain Polygons)*	Shift Detection Tool Triangulation Tool *(3D Terrain Elevation Sample Points)*
Performer Scene Graph [P,A] *(Silicon Graphics in-memory data structures)*	**Partial** *(Requires Mak VR-LINK and SGI Performer- not integrated into ZCAP 4.1)*	**Partial** *(Requires Mak VR-LINK and SGI Performer- not integrated into ZCAP 4.1)*	**Partial** *(Requires Mak VR-LINK and SGI Performer- not integrated into ZCAP 4.1)*	**Partial** *(Requires Mak VR-LINK and SGI Performer- not integrated into ZCAP 4.1)*
MultiGen™ OpenFlight® [O] *(Revision - 14.2)*	**FULL**	**Not Applicable**	**FULL**	**FULL**
S1000 [P,A]	**FULL**	**NONE** *(Has not been developed)*	**FULL**	**FULL**
SIF/HDI [O]	**FULL**	**FULL**	**FULL**	**FULL**
E&S GDF [P]	**NONE** *(Cannot assess - do not have at IST)*	**NONE** *(Cannot assess - do not have at IST)*	**NONE** *(Cannot assess - do not have at IST)*	**NONE** *(Cannot assess - do not have at IST)*
E&S ESIG 2000 Run-Time Data Base (RTDB) [P] *(IST ESIG 2000 compatible)*	**Partial** *(Requires Mak VR-LINK and ESIG 2000 host, and SGI performer - Not integrated into ZCAp 4.1)*	**Not Applicable**	**NONE** *(Has not been developed)*	**Partial** *(Requires Mak VR-LINK and ESIG 2000 host, and SGI performer - Not integrated into ZCAp 4.1)*
Lockheed Martin TARGET™ [P]	**NONE** *(Cannot assess - do not have at IST)*	**NONE** *(Cannot assess - do not have at IST)*	**NONE** *(Cannot assess - do not have at IST)*	**NONE** *(Cannot assess - do not have at IST)*
Defense Mapping Agency Digital Terrain Elevation Data [O]	**NONE** *(Has not been developed)*	**Not Applicable**	**Not Applicable**	**NONE** *(Has not been developed)*
Defense Mapping Agency Digital Feature Analysis Data [O]	**Not Applicable**	**NONE** *(Has not been developed)*	**NONE** *(Has not been developed)*	**Not Applicable**
CCTT Model Reference Terrain Database (MRTDB) [O]	**FULL**	**NONE** *(Will not be developed)*	**NONE** *(Will not be developed)*	**FULL**
CCTT SIF++ [O]	**FULL**	**NONE** *(Will not be developed)*	**NONE** *(Will not be developed)*	**FULL**

LEGEND: P: PROPRIETARY
O: OPEN (NON-PROPRIETARY)
A: API ACCESSIBLE

Full: Format will be input compatible with ZCAP 4.1
Partial: Format will be converted to ZCAP 4.1-input-compatible format, but some conversion steps must be done outside ZCAP 4.1
None: Format cannot be input into ZCAP 4.1
Not Applicable: A particular data type (e.g. 2D vector features, etc.) is not supported by the TDB format.

*NOTE: This table describes terrain database format input compatibility with ZCAP 4.1; it does not imply that ZCAP 4.1 has the capability to convert between the formats listed in column 1. This table does not include ZCAP 4.1 image processing tools, which currently operate on PGM format image files.

0749-7148

ZCAP Utilization

- **I/ITSEC '93-96**

- **HLA PPF Experiments**

- **SIF Analysis**

- **IST Internal Research**
  - *Human Factors Studies*
  - *CGF/Mission Planning*
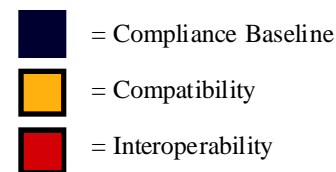
- **CCTT (In Process)**

High Level Interoperability Process
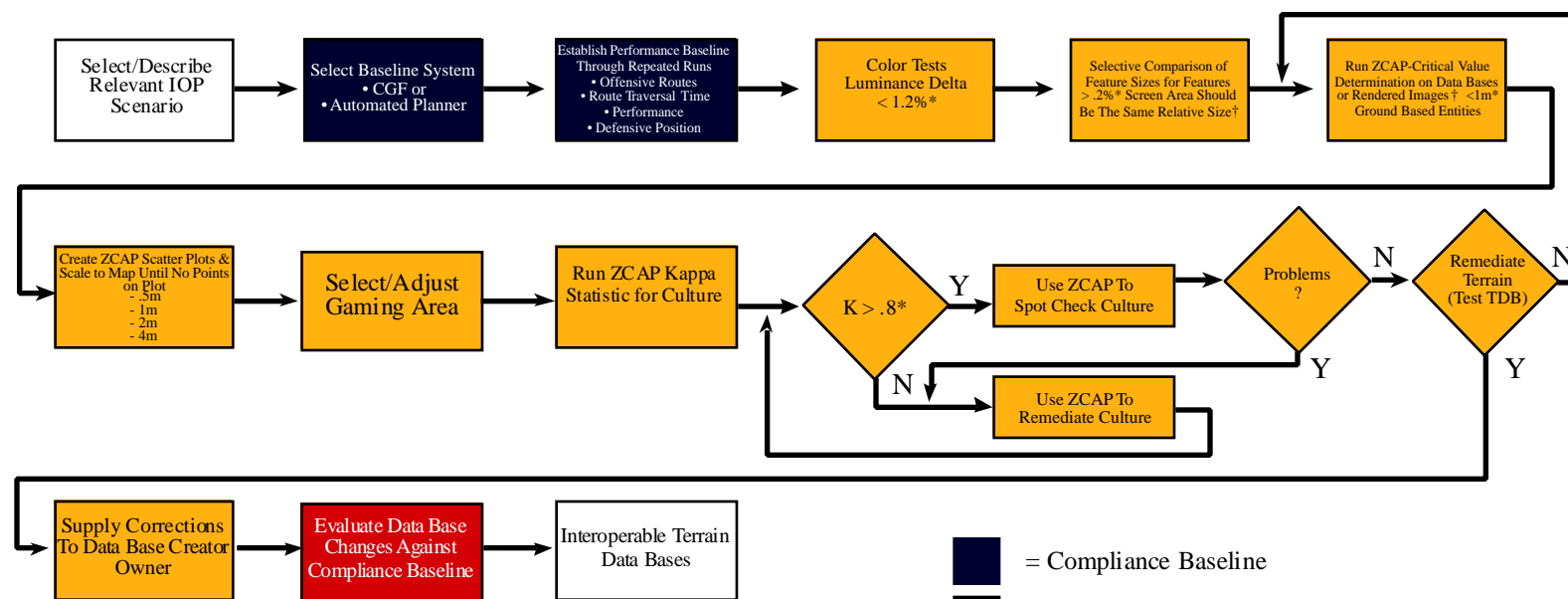
Repeated Z-CAP runs w/o improving critical value or K implies interoperability problems. May want to modify baseline system or alter objectives.

Critical value < 1m indicates interoperable terrain.

= Compliance Baseline

= Compatibility

= Interoperability

*Preliminary Value
†Definitive Methods Not Determined

0742-7137

Multi-Resolution Interoperability
(Remediation Methodologies)

- **IST Vertex Adjustment Method**
  - *Absolute Minimum*
  - *Maintains Polygonalization Method*
  - *Maintains Polygon Counts*
- **Early Tests Show Critical Value Reduction of 20% to 90+%**
- **Computationally Intensive (N^3 Problem)**
  - *3Km x 3Km, 100 m. grid takes 5 min.*
  - *Algorithms Can Be Optimized*
- **Currently Does Not Correct Culture/Cuts & Fills**

Additional Multi-Resolution Research

- **Non-Polygonal Representations**
- **Non-Visual Representations**
- **Data Content Tracking Mechanism**
- **Effects of Generalized Ground Interactions**
- **Non-Ground Based Environments**
- **More Comprehensive Interoperability Assessments**
- **Diverse Base of Approaches**
- **Forums for Discussions**